THE SESSILE TUNICATA

BY

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WITH SEVENTEEN TEXT-FIGURES

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CONTENTS

SUMMARY

TWENTY-FOUR species of sessile Ascidians are recorded from the Red Sea, Gulf of Aden and Southern Arabia. These include three species which are new to science. The Ascidian fauna of this area is more closely related to that of the East Indies-Northern Australian region than to other adjacent areas.

INTRODUCTION

The following report deals with twenty-four species of sessile Tunicates (Class Ascidiacea) from the Red Sea and Indian Ocean area.

LIST OF SPECIES IN THE COLLECTION

I. ENTEROGONA

Podoclavella detorta Sluiter.
Stomozoa murrayi, n. sp.
Archidistoma murrayi, n. sp.
Archidistoma parva (Sluiter) ?
Didemnum moseleyi (Herdman).
Didemnum psammotodes Sluiter.
Didemnum candidum Savigny.
Trididemnum lüderitzi Michaelsen.
Trididemnum aspiculatum, n. sp.
Lissoclinum capense (Hartmeyer).

Diplosoma spongiforme (Giard).
Synoicum hypurgon (Michaelsen) var. *arenosum* nov.
Aplidium violaceum Hartmeyer.
Aplidium savignyi Michaelsen, var. *translucidum* nov.
Ascidia melanostoma Sluiter.
Ascidia malaca Traustedt.

II. Pleurogona

Styela canopus Savigny.
Polycarpa thelypanes (Sluiter).
Polycarpa aurita (Sluiter).
Polycarpa cryptocarpa (Sluiter).
Alleocarpa similis (Sluiter).
Botrylloides nigrum Herdman.
Hexacrobylus sp. ?.
Herdmania momus (Savigny) var. *kyamanensis* Michaelsen.

Of these, three species are new to science, one of them being referred to a monotypic genus, Stomozoa, in a new Subfamily, Stomozoinae, of the family Clavelinidae. Sessile Tunicates were taken only at stations in the Red Sea, Gulf of Aden and around the south coast of Arabia ; none were taken from the central Indian Ocean, nor from stations on the west coast of India and the Maldive Archipelago, nor on the east coast of Africa.

The collection is of particular interest in that it shows the very wide range of distribution of the species present in the area. Only three species, *Styela canopus*, *Stomozoa murrayi* and *Herdmania momus* var. *kyamanensis* are limited to the Red Sea area. Most other species have a wide range into the Malayan, East Indies, North Australian area and *Polycarpa cryptocarpa* and *Didemnum moseleyi* have also been recorded from Japan. Of the fauna taken previously off south east Africa only *Lissoclinum capensis*, *Didemnum psammatodes*, *Aplidium violaceum* and *Diplosoma spongiforme* were taken in the Red Sea and adjacent areas ; *Tridemnum lüderitzi* has been recorded from South West Africa and north west Australia.

The collection is housed in the British Museum (Natural History).

I. Order ENTEROGONA.

Sub-Order KRIKOBRANCHIA Seeliger.

Family Clavelinidae Forbes & Hanley.

Subfamily Clavelininae Seeliger.

Podoclavella detorta Sluiter.

(Text-fig. 1.)

Sluiter, 1905.

Collection.—Sta. 53, 19° 22′ N., 57° 53′ E., south east Arabia ; Triangular dredge. 13·5 m., 2.xi.33.

Previous Records.—7° 55′ S., 114° 26′ E., East Indies.

Colony.—A large number of individuals 2–3 cm. long, completely separate from one another except where the test is joined basally.

Test: Is hard and gelatinous except where it covers the thorax where it is soft and thin. Due to the delicate nature of the test around the thorax this part of the animal is very often lost in these colonies. The test enclosing the zooid is about 2–3 cm. long.

Zooid (Text-fig. 1): The zooid is about 1·5 cm. long and does not occupy the whole length of the test. Thorax is only 2–3 mm. long; the length of the zooid is mainly occupied by the long neck containing narrow oesophagus and rectum. There is a slight expansion posteriorly for the smooth stomach and loop of the intestine.

Apertures: On the thorax there are muscles radiating out from the apertures which are both smooth rimmed and sessile and both on the side of the zooid (Text-fig. 1). The atrial opening is most anterior and the branchial opening posterior to it, so that the zooid is more or less upside down.

Thorax: There are 20 branchial tentacles. There are 4 rows of stigmata arranged parallel to the long axis of the zooid, with about 30 stigmata in each row. The dorsal lamina consists of 3 languets; the endostyle extends half way around the branchial sac on its posterior and lateral aspect, and the oesophagus, leaving the branchial sac antero-laterally runs down the side of the branchial sac inside the rectum.

Abdomen: The stomach is smooth walled. The rectum curves around the anterior end of the zooid and opens just above the atrial opening. The anus is very extended in these specimens and the six lobes described by Sluiter are not apparent. Gonads were not observed.

Discussion.—The thorax in these specimens is smaller than that described by Sluiter. The orientation of the branchial sac and the relative positions of the apertures are, however, distinctive and the species are undoubtedly identical. This disposition of the apertures is reminiscent of the situation in *Pyura pachydermatina* Herdman and related species (Kott, 1952) which are simple, stalked forms where the branchial aperture is posterior to the atrial aperture in relation to other parts of the animal.

In Sluiter's species the endostyle is much shorter and the oesophagus opens from the ventral aspect of the branchial sac. The two records of this species are from widely separated regions and it is therefore possible that the species has a general distribution in the Indian Ocean–East Indies area.

Subfamily Stomozoinae, nov. subfam.

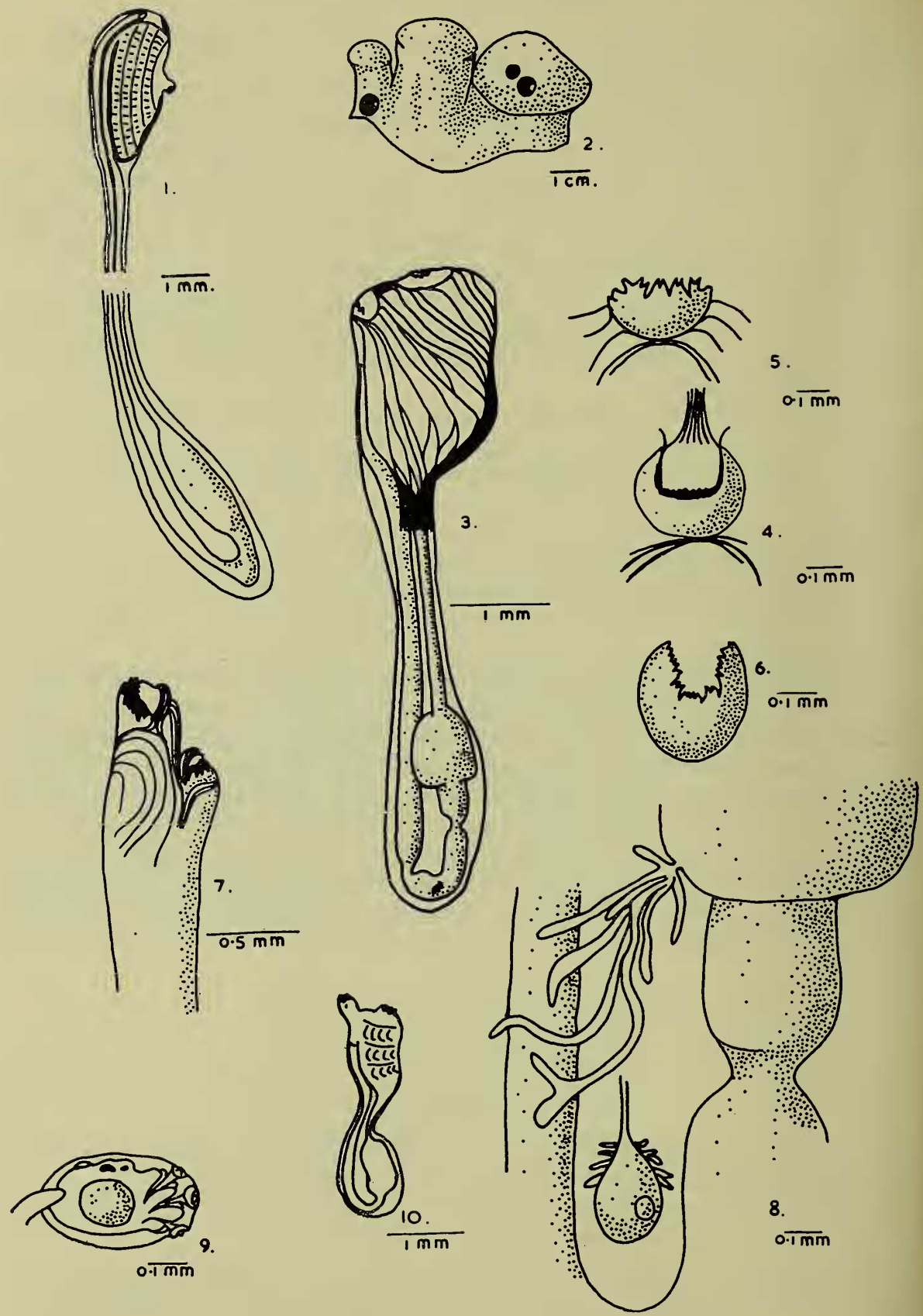
Stomozoa murrayi, nov. gen., n. sp.

(Text-figs. 2–8.)

Collection.—Motor boat station 1, 13° 39′ 30″ N., 42° 43′ E., Bay between Great Hanish and Suyul Hanish Islands, Red Sea; dredge, 13 fathoms, 17.ix.33.

Colonies (Text-fig. 2.).—Two colonies are available, composed of 3–4 club-shaped rounded lobes, 0·5 cm.–2·5 cm. in diameter and joined basally.

Test hard and gelatinous in preserved specimens, with a slightly purple colour, the pigment especially accumulated at the ends of the blood vessels which ramify through the test. The smooth surface of the colony is sometimes interrupted by the openings of large canals which traverse the test and into which smaller canals ramifying through the



TEXT-FIGS. 1—10.

1. Thorax of *Podoclavella detorta* Sluiter. 2. Colony of *Stomozoa murrayi* n. sp. 3. Zooid of *Stomozoa murrayi* n. sp. 4. Atrial opening to show closed lip of *Stomozoa murrayi* with protective pouch removed. 5. Pouch of atrial opening of *Stomozoa murrayi* n. sp. 6. Pouch of Branchial opening of *Stomozoa murrayi* n. sp. 7. Extended thorax of *Stomozoa murrayi* n. sp. to show apertures open. 8. Gastric gland and gonads of *Stomozoa murrayi* n. sp. 9. Larva of *Archidistoma murrayi* n. sp. 10. Zooid of *Archidistoma parva* (Sluiter).

test discharge. At other times, the smaller canals open either on the surface or in small rounded fossae on the surface. This system of canals presumably provides for a circulation of water through the rigid test in which zooids are only sparsely distributed. There are only 4–8 zooids in each lobe, more or less vertically placed and opening around the upper surface of the lobe. Throughout the test, however, there are isolated abdominal portions of zooids, which have been "budded off" the abdomen for the vegetative multiplication of zooids (Berrill, 1950, p. 48).

From the posterior end of the zooids there is a blood vessel which ramifies through the test. Zooids open on the surface of the test with the two apertures very close together. The openings are very small, but the test conforms more or less with the structure of the mantle around the apertures as described below.

Zooids (Text-fig. 3) : These are found away from the surface of the colony and careful dissection must be made to expose them. They are about 1 cm. long, of which the abdomen is 0·6 mm. and the thorax 0·4 mm., and are about 0·2 mm. in mean thickness.

Apertures : The branchial and atrial apertures are sessile, and terminal and antero-dorsal respectively. The lips of the apertures provide the principal distinguishing character of the species. Each aperture consists of a flap-like lip with the free border indented to form about 8 small rounded lobes. The lip is ventral on the atrial siphon and dorsal on the branchial siphon. In a contracted zooid, this lip closes against the smooth rimmed lower or dorsal border of the opening for the atrial aperture and against the ventral border of the opening for the branchial aperture. (Text-fig. 4). The apertures when closed, therefore, are transverse but are covered by a pouch-like flap of tissue (Text-figs. 5. 6) with deeply lobed borders. and attached to an area around the apertures on the side opposite to the lips already described. The area for the attachment of the pouch on the atrial siphon is semicircular and the resultant flap is half a circle (Text-fig. 5), whereas the area for the attachment of the branchial pouch extends dorsally around the sides of the aperture and the resultant pouch is crescent shaped (Text-fig. 6). The apertures in the extended state are shown in Text-fig. 7.

Muscles : The part of the mantle forming the "pouches" protecting the apertures is not very muscular but there are strong muscles around the base of the pouch where it is attached to the rest of the body ; there is also a strong band of muscle into the base of the "lips" of the apertures and transversely across the base of the lip (Text-fig. 7).

The thorax has about 14 muscle bands on each side (Text-fig. 3) which run obliquely towards the dorsal aspect and join, on each side of the abdomen, into a wide muscle band running the length of the abdomen and practically completely enclosing it.

Branchial sac : Branchial tentacles are simple and of varying sizes. There are 26 rows of oval stigmata and about 60 stigmata in a row, on each side of the body ; wide transverse vessels are present between the stigmata.

Abdomen : The oesophagus is fairly long and opens into a rounded smooth-walled stomach about half-way down the abdomen. There is a duodenal constriction and another constriction separating the mid-intestine from the rectum. The gastric gland is very well developed, composed of branching tubules which wind across the ascending rectum (Text-fig. 8).

Gonads (Text-fig. 8) are present superficially on the right side of the abdomen just posterior to the stomach ; the testes are deep to the one egg ovary and consist of many short tubules. The gonoducts run anteriorly through the superficial connective tissue

surrounding the abdomen ; they are very delicate and only with difficulty separated from the connective tissue and muscles.

Discussion.—This species has been placed in a new subfamily of the Clavelinidae, of equal status with the subfamilies Polycitorinae and Clavelininae, on account of the very great specialization of the apertures, the superficial situation of the gonads and the great development of the gastric gland. The two latter characters may be secondary and not of any phylogenetic importance and it is interesting to observe that *Rhodosoma* (Kott, 1952), a simple form of the sub-order Dictyobranchia which has also a highly specialized and muscular organization in the apertures, possesses a well-developed gastric gland too.

The subfamily has probably been derived from the Clavelininae by an elaboration of the apertures ; in the Polycitorinae, also derived from the Clavelininae, the zooids have much less modification of the apertures, tend to be grouped together in the test to form systems, and have, except in rare cases, reduced numbers of rows of stigmata.

Polycitor torensis (Michaelsen, 1921) also from the Red Sea, has similar body musculature and a similar disposition of the gonads. There are, however, only 9 rows of stigmata and many less stigmata in each row, the stomach is folded, the branchial and atrial openings are not modified and the test differs.

Subfamily Polycitorinae Michaelsen.

Archidistoma murrayi n. sp.

(Text-fig. 9.)

Collection.—Sta. 45, 18° 03′ 30″ N., 57° 02′ 30″ E., off southern Arabia. Triangular dredge, 40 metres, 29.x.33.

Colonies.—Many colonies consisting of numbers of long lobes 2·5 cm. long and 5 mm. thick arising from a common base. Each lobe contains about 6 zooids in separate compartments and the free ends of the lobes are occupied by rounded protuberances from these compartments, and support the openings of the zooids.

Test : This is completely filled and brittle, with sand throughout.

Zooids are 2·5–3·00 mm. long and the abdomen is about one and a half times the length of the thorax. A brood pouch is present on the right side of the branchial sac, consisting of an expansion of the distal end of the oviduct and containing 6–7 embryos in two rows.

Apertures : Both the branchial and atrial siphons are 6-lobed and open separately to the surface. They are both fairly short. The branchial siphon is terminal and the atrial siphon is antero-dorsal.

Muscles : There are strong transverse and longitudinal muscles in the walls of the thorax, but longitudinal muscles only on the abdomen, in two bands on its ventral aspect.

Thorax : There are 3 rows of stigmata with about 16 in each half row and wide horizontal membranes are present between them. In the middle of the anterior row the stigmata are particularly long, but are very much reduced in length towards the ventral and dorsal surfaces.

Abdomen : The oesophagus is very long and wrinkled anteriorly, due to contraction. The stomach is two-thirds of the way down the abdomen and is round and smooth. There is no posterior stomach and the intestine enters the very much wider rectum in the pole of the loop.

The rectum is also coiled and folded anteriorly, like the oesophagus. The testes lobes are many and pear-shaped ; they are situated in and around the alimentary loop posterior to the stomach and particularly on the left side of the loop. The ovary is to the right of the testes in the gut loop. The vas deferens and oviduct is wrinkled like the oesophagus and intestine.

Larvae (Text-fig. 9) : The fully formed embryo is about 0·5 mm. in length. There are four paired ampullae on the ridges on either side of the three suckers, which are arranged in the median line.

Discussion.—Externally this species is very similar to colonies of *Archidistoma aggregatum* Garstang (Berrill, 1950), particularly in respect of the sand-filled test separating the zooids, the separate openings of the apertures to the exterior and the absence of common cloacal apertures or systems of any sort. The most anterior portions of the zooids, however, are not so markedly separated from one another as is the case in *A. aggregatum*. This, however, is merely a matter of degree and *A. murrayi* may be considered as intermediate between *Archidistoma aggregatum* and the species of *Eudistoma* embedded in a common test. The larvae, the alimentary canal, body-wall musculature and gonads are similar in the two species although the colony, zooid and larvae are smaller in *Archidistoma aggregatum*. Berrill (1950) and Kott (1952*a*) have suggested that *Archidistoma* and *Eudistoma* are separated on only very slender grounds. Therefore, in this paper the generic name *Archidistoma* is adopted for a species of the subfamily Polycitorinae with both apertures six-lobed, a smooth stomach and three rows of stigmata. The zooids of *Eudistoma miniaceus* (Sluiter) (Sluiter, 1909) have a similar alimentary canal, branchial sac and gonads to the present species and both apertures open separately to the exterior ; the form of the anterior row of stigmata and the nature of the test, however, differ. Millar (1953) has described a sand-covered species, *Eudistoma ramosum*, from West Africa, which is also similar in many respects, but the lobes of the colony are longer. *Archidistoma murrayi*, therefore, is most closely related to *Archidistoma aggregatum* found in the English Channel and on the coast of North Carolina, U.S.A.

Archidistoma (*Eudistoma*) *parva* (Sluiter) ?

(Text-fig. 10.)

Sluiter, 1900.

Collection.—Sta. 24, 11° 53′ 42″ N., 51° 13′ 12″ E., off Cape Guardafui, Somaliland, Conical dredge, 73–200 metres, 9.x.33.

Previous Records.—Laysan, Hawaiian Islands.

Colony.—One colony only is available. It is cylindrical, 2 cm. high and 5 mm. in diameter. The test is semitransparent, soft and fleshy throughout. The head of the colony is naked but the basal half is coated with sand. There are numerous zooids in the colony, arranged radially over the surface and sides of the head, but no systems are obvious.

Zooids (Text-fig. 10) are 2–3 mm. long. The thorax and abdomen are more or less equal.

Apertures : The branchial aperture is on a short siphon and six-lobed ; the atrial aperture is on a long siphon from the antero-dorsal corner of the thorax and is also six-lobed.

Muscles : There are strong longitudinal muscles on the thorax but musculature on the abdomen is weak.

Thorax : There are three rows of long rectangular stigmata, with about 6–8 stigmata in each half-row.

Abdomen : This is sometimes folded back on the thorax but this condition may be due to preservation. The alimentary loop is short ; the stomach is large, smooth and rectangular and occupies the posterior half of the abdomen. The intestine and rectum are not differentiated from one another. The gonads are present alongside and posterior to the gut loop. There are many testes lobes.

Discussion : This species is distinguished from others described from this and adjacent areas by the short alimentary loop, the large stomach and the long atrial siphon. It agrees very well in all aspects with Sluiter's description of *A. parva* but the identification can only be regarded as provisional as only one small colony is available for examination. It seems unlikely that a species which appears to be uncommon would occur in two areas so remote from one another.

Family Didemnidae Giard.

Didemnum moseleyi (Herdman).

(Text-figs. 11, 12.)

For literature and synonymy see Tokioka, 1953.

Collection.—Sta. 53, 19° 22′ 36″ N., 57° 53′ 00″ E., south-east Arabia. Triangular dredge 13·5 m. 2.xi.33 ; Sta. 45, 18° 03′ 30″ N., 57° 02′ 30″ E., off southern Arabia. Triangular dredge, 38 m., 29.x.33.

Previous Records.—Phillipines, East Indies, Japan.

Colony.—Thin, white, investing colonies.

Test : All layers throughout are filled with spicules. Branchial apertures regularly spaced over the surface and conspicuous by the spicules over their lobes. Common cloacal openings are present. The common cloacal cavity is extensive and traversed by the entire thoracic part of the zooids,which are enclosed in a thin layer of test with fewer spicules than are present elsewhere. This common cloacal cavity therefore divides the test into two layers, an upper, thin, layer level with the branchial siphons of the zooids and a lower, thicker, layer enclosing the abdomen and larvae of the zooids. In the colony from Sta. 53, even the abdomen of the zooids is present above the basal layer of test.

Spicules (Text-fig. 11) are stellate, 20μ to 30μ in diameter with six, ten or twelve arms in optical section. The smaller spicules with a greater number of arms are most plentiful and larger spicules with a smaller number of arms are rare. In the colony from Sta. 45 there are occasional very large spicules of 50μ diameter, with six very pointed rays, in the surface of the basal layer of the test, *i.e.* in the floor of the common cloacal cavity.

Zooids : The branchial siphon is distinctly six-lobed; the atrial aperture is huge, exposing most of the dorsal surface of the thorax to the common cloacal cavity. There are about six stigmata in each of the four rows. No thoracic organ is evident. The testis is a single lens-shaped organ surrounded by five to six coils of the vas deferens. The thorax and abdomen are of equal size.

Larvae (Text-fig. 12) are present in the basal layer of the test, are 0·3 mm. long and have four pairs of ampullae in a line on each side of the suckers, arising from an outgrowth ventral to the developing zooid.

Discussion.—This specimen generally conforms with descriptions given for the species and Sluiter (1905) has remarked on the similarity of this species to *D. bistratum* (Sluiter) which has been recorded from the head of the Gulf of Aden (Sluiter, 1905). The spicules in the latter species are completely different from those of *D. moseleyi* and this seems to be one of the few characters separating the adults of the two species. Tokioka (1953) has described the larvae of *D. moseleyi* from Japanese waters and the fully developed larvae, although slightly larger, are similar to those of the present specimens. These specimens must, therefore, be referred to *D. moseleyi*, despite the fact that this species has not previously been reported from any area west of the East Indies.

Didemnum psammatodes Sluiter var. *ianthinum* Sluiter.

(Text-figs. 13, 14.)

For literature and synonymy see Michaelsen, 1921.

Collection.—Sta. 45, 18° 03′ 30″ N., 57° 02′ 30″ E., off southern Arabia. Triangular dredge, 40 m., 29.x.33.

Previous Record.—Mozambique.

Colony.—Thin investing colonies or thicker lobed colonies. The common cloacal cavity is extensive at the level of the thoraces of the zooids and, particularly in the thicker colonies, there are infra-abdominal lacunae in the basal layer of the test. Branchial openings are distinctly six-lobed and evenly spaced over the surface. Some common cloacal openings are present. Over the surface, particularly of the thick colonies, the test is raised into spicule-filled pointed papillae ; in other colonies these papillae are present on small parts of the surface only.

Spicules (Text-fig. 13) : These are plentiful just below the surface in the upper layer of the test. They are more sparse in the test surrounding the abdomen and are practically absent from the basal layer of test. They are variable in form, but seldom of greater diameter than 25μ. The most plentiful types are of the usual stellate form with 7–10 conical rays in optical section. Sometimes the points of the rays are rounded and occasionally the rays are very fine and needle-like ; very rarely there are cylindrical spicules with about four conical rays on either end.

Zooids : The thorax and abdomen are both about 0·42 mm. There are four rows of stigmata with about five stigmata in each row. The two posterior rows are shorter than the anterior ones. The testis is a single, lens-shaped, lobe surrounded by 6–8 coils of the vas deferens.

Larvae (Text-fig. 14) 0·4 mm. long and of particularly sturdy form. There are six pairs of ampullae arranged along the ridges on either side of the suckers and two pointed processes in the median line alternating with the suckers.

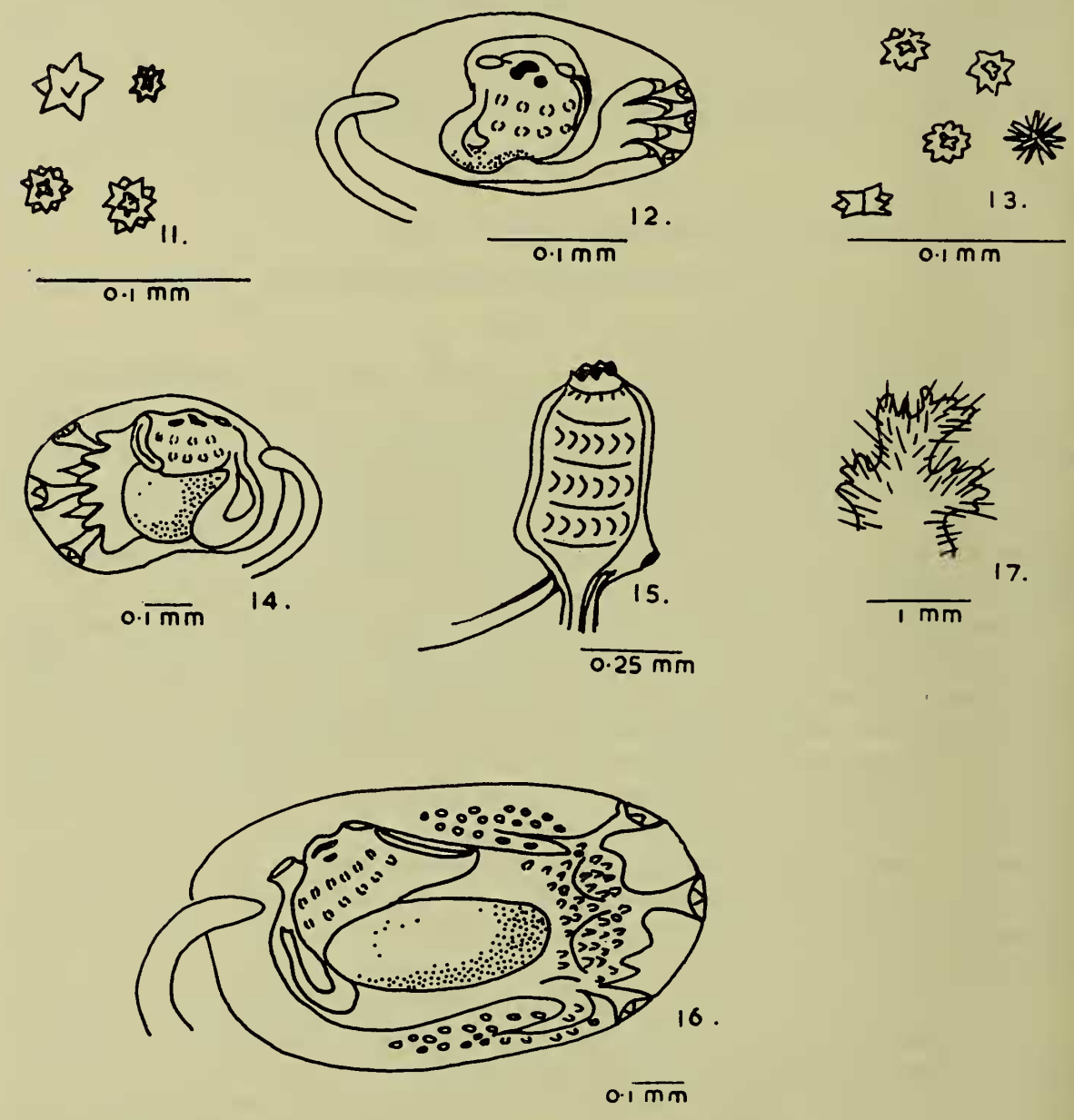
Discussion.—Both the spicules, the common cloacal cavity and the zooids agree with descriptions of *D. psammatodes* var. *ianthinum*. Although var. *skeati* (Michaelsen, 1920) has been taken previously from this area, the present specimens do not contain faecal pellets in the test, as is the case with this and other varieties of this species. Unless, therefore, the varieties have been transported artificially from one area to the other, it seems unlikely that the " varieties " of this species are geographical subspecies.

Didemnum candidum Savigny.

For literature and synonymy see Van Name, 1945.

Collection.—Sta. 45, 18° 03′ 30″ N., 57° 02′ 30″ E. off southern Arabia. Triangular dredge, 40 m., 29.x.33.

Previous Records.—Red Sea, Indian Ocean, Malaya, West Indies, Bermudas, Brazil.



Text-figs. 11—17.

11. Spicules of *Didemnum moseleyi* (Herdman). 12. Larva of *Didemnum moseleyi* (Herdman). 13. Spicules of *Didemnum psammatodes* v. *ianthinum* Sluiter. 14. Larva of *Didemnum psammatodes* v. *ianthinum* Sluiter. 15.—Thorax of *Trididemnum aspiculatum* n. sp. 16. Larva of *Aplidium violaceum* Hartmeyer. 17. Lobe from around branchial aperture of *Hexacrobylus* sp. ?

Colony.—White and brittle with closely packed spicules. Common cloacal cavities obscured.

Spicules almost rounded, 50μ in diameter with only traces of rays.

Zooid : Thorax twice the size of the abdomen. The abdomens of the zooids lie almost horizontally with the thoraces. About eight stigmata in each row. There are two testis lobes and five to six coils of the vas deferens.

Discussion.—The tightly packed spicules, obscured common cloaca and two testis lobes are distinctive.

Tridemnum lüderitzi Michaelsen.

For literature and synonymy see Michaelsen, 1930.

Collection.—Sta. 45. 18° 03′ 30″ N., 57° 02′ 30″ E., off southern Arabia, Triangular dredge, 40 m., 29.x.33.

Previous Records.—Shark's Bay, Western Australia ; Lüderitz-Bucht, S.W. Africa ; Ambrizette, Angola.

Colony.—Thick and rounded, up to 1 cm. thick. Branchial apertures regularly scattered over the surface, six-lobed. Common cloacal cavities are present at the level of the abdomen of the zooids and at the level of the neck joining the thorax and abdomen. No obvious systems are present.

Spicules are present throughout the test. They are 40–50μ, stellate with about eight rays in optical section.

Zooids : Thorax 0·85 mm. long and twice the size of the abdomen. The branchial aperture is on a fairly short siphon with six lobes. The atrial aperture is on a long, sometimes trumpet-shaped siphon, rising from the middle of the dorsal surface of the thorax, and directed posteriorly. There are areas devoid of stigmata anterior and posterior to the three rows of stigmata in the branchial sac, of which there are about ten in each row.

The alimentary canal has a large rectangular stomach, mid-intestinal constriction and rectum, and is covered almost completely on one side by the large lens-shaped testis with six coils of the vas deferens.

Discussion.—This species is closely related to *T. natalense* Michaelsen, from the Barrier Reef and Natal and to *T. opacum* from California. It is distinguished from the latter by its extensive cloacal system, and from the former by the arrangement and form of the spicules.

Tridemnum aspiculatum n. sp.

(Text-fig. 15.)

Collection.—Sta. 43, 17° 29′ N., 55° 47′ E., Kuria Thuria Is., off southern Arabia, Otter Trawl, 83–100 m., 28.x.33.

Colony.—A small free lobe 1 × 1·5 cm. The test is transparent without spicules. Basally there are sand grains and shell particles embedded in the test. The zooids are closely packed throughout. The colony has a central common cloaca with one aperture terminally. Strands of the test form connectives across this common cloacal cavity and are filled with what appear to be eggs, although no developing embryos were found. Common cloacal canals ramify through the test and open into the central cloacal cavity.

Zooids (Text-fig. 15) are minute and measure only about 0·7 mm. in all. The branchial siphon is of moderate size with six very well defined lobes. The atrial siphon, opposite the last row of stigmata, is a short, posteriorly directed, tube with a smooth margin. The branchial sac has three rows of 8–10 long, rectangular, stigmata. The alimentary canal is of the usual form with an almost spherical smooth stomach ; the loop of the gut is almost horizontal and cradles a large, one-egg, ovary and a small single-lobed testis with seven coils of the vas deferens.

Discussion.—The small zooids, transparent test without spicules and central common cloacal cavity are distinctive for the species. The form of the colony is very similar to *Didemnum sycon* Michaelsen (1920).

Lissoclinum capense (Hartmeyer).

Hartmeyer, 1912.

Collection.—Sta. 53, 19° 22′ 36″ N., 57° 53′ 0″ E., off southern Arabia. Triangular dredge, 13·5 m., 2.xi.33.

Previous Record.—Cape of Good Hope.

Colony.—Irregular investing layer, about 4 mm. thick. There is a large circular common cloacal canal running just inside the margin of the colony. The zooids are especially plentiful around this canal and others are scattered less densely over the rest of the surface of the colony. Black pigment is present scattered through the test and particularly in the vicinity of the common cloacal canal.

Spicules are very plentiful in the surface layers but not in the deeper parts of the test. They are stellate with short conical arms and are 30–50μ in diameter.

Zooids : There is a fairly long branchial siphon with six lobes ; the atrial siphon rises from the mid-dorsal aspect of the thorax and is long and trumpet-shaped, directed laterally or posteriorly. There are four rows of stigmata, with ten in each row. The abdomen is of the usual form ; the vas deferens is straight and there are two testis lobes.

Discussion.—The "Leptoclinides" form of the atrial siphon and testis with its duct are similar to those Hartmeyer has described. The common cloacal cavities of Hartmeyer's specimens are, however, extensive whereas that in the present colony is well-developed only in the margins of the colony. Hartmeyer's specimens also contain spicules having a greater size range than those in this collection. Despite these differences, however, the species, if not identical, are obviously closely related and there is insufficient evidence, on variations of the cloacal cavity and spicules, to place the present single colony in a different species.

Diplosoma spongiforme (Giard).

For literature and synonymy see Michaelsen, 1920.

Collection.—Sta. 10, 13° 31′ 00″ N., 42° 31′ 00″ E., southern Red Sea, Otter trawl, 55 m., 17.ix.33.

Previous Records.—Seychelles, Zanzibar Channel.

Colony.—One very small, regularly oval colony, 5 mm. long. The test is spongy with large common cloacal spaces throughout.

Zooids are very small and measure only about 1 mm. The thorax and abdomen are of equal size about 0·34 mm. The branchial siphon is six-lobed ; the atrial aperture is wide and there is no siphon. There are four rows of stigmata with six in each row.

There are two testis lobes and a straight vas deferens. No ovary is evident and the testis lobes are very small and discernible only with difficulty.

Discussion.—Although this is a very young specimen, the form of the cloacal system, the size of the zooids, the branchial sac, atrial aperture and gonads all place it unmistakably as a specimen of *D. spongiforme*. Michaelsen (1920) describes both dioecious and hermaphrodite colonies and the absence of any apparent ovary in this colony may be because it is a male colony, rather than merely due to its youth.

Family Polyclinidae Verrill.

Subfamily Polyclininae Adams.

Synoicum hypurgon (Michaelsen) var. *arenosum* nov. var.

For literature and synonymy see Michaelsen, 1930.

Collection.—Sta. 45, 18° 03′ 30″ N., 57° 02′ 30″ E., off southern Arabia, Triangular dredge 38 m. 29.x.33.

Previous Records.—*f. typicum*: North Is., New Zealand; *f. galei*: Fremantle, Western Australia.

Colony.—Sandy, investing colonies about 2–3 mm. thick. The test is filled with sand throughout. No systems are obvious.

Zooids: The zooid is 4·5 mm. long, of which the thorax is 1·5 mm., the abdomen 0·5 mm. and the post-abdomen 2·5 mm. The branchial aperture is six-lobed and the atrial aperture antero-dorsal with a large stout atrial languet. There are sixteen rows of stigmata with about eight in each row.

There are about ten thin, well spaced bands of muscle down either side of the thorax continuing along the abdomen without very much concentration into broader muscle bands. These thin bands of muscle therefore practically completely encase the abdomen. The stomach is smooth although, when relaxed, there are apparent folds which are merely artifacts of the collapsed stomach.

Discussion.—The zooids of these colonies are very similar to those of previously described forms of *S. hypurgon*. The very sandy nature of the test is, however, distinctive and characteristic. *S. hypurgon* is apparently a widely distributed species with many distinctive varieties.

Aplidium violaceum Hartmeyer.

(Text-fig. 16.)

Hartmeyer, 1912.

Collection.—Sta. 53, 19° 22′ 36″ N., 57° 53′ 00″ E., off southern Arabia. Triangular dredge, 13·5 m., 2.xi.33.

Previous Records.—Dar-es-Salaam, Zanzibar.

Colony.—Flattened, but rounded masses. The surface of the colony is smooth but there is sand investing the basal part and sand particles are scattered through the rest of the test. The test is soft and semi-transparent and the surface layer is spongy with canals and lacunae. Numerous common cloacal openings are present on the surface, but no systems were distinguished.

Zooids are small and only sparsely distributed in the test. The branchial aperture is six-lobed and the atrial aperture antero-dorsal with a small slightly bifid lip. There are fifteen rows of stigmata with 12–14 in each row. Larvae are present in a brood pouch at the side of the branchial sac. The stomach has 8–10 folds which, on the dorsal side against the ascending rectum, are broken up into 2–3 sections.

Larvae (Text-fig. 16) are large, 0·9 mm. long. There are three suckers, with a single median ampulla between the dorsal and middle suckers and two median ampullae between between the middle and ventral suckers. There are numerous epidermal vesicles budding off from the anterior part of the larva in the region of the suckers and ampullae and extending posteriorly in the mid-dorsal and mid-ventral regions. The larvae are most reminiscent of *Aplidium proliferum* (Milne Edwards) (Kott, 1952*a*) from the English Channel. The epidermal vesicles are exceedingly numerous and it is interesting to note that species of this genus from Antarctic waters have very few of them.

Discussion.—Although the colony of *A. violaceum* described by Hartmeyer does not contain the sand scattered throughout the test, and the present specimens have lost any pigmentation, the zooids are similar in all features. The colonies and zooids are similar to *A. glabrum* Verrill and *A. californicum* (Ritter and Forsyth) and these species are undoubtedly closely related to the present colonies.

Aplidium savignyi Michaelsen *var. translucidum* nov. var.

Michaelsen, 1919.

Collection.—Sta. 43, 17° 29′ 00″ N., 55° 47′ 00″ E., Kuria Muria Islands, off southern Arabia. Otter trawl, 83–100 m., 28.x.33.

Previous Records.—Gulf of Suez (var. *typicum*).

Colony.—Rounded glassy lobes, 2 cm. high and 2 cm. in diameter. They are attached to the substrate by a narrow base. The test is completely transparent and soft and the zooids are clearly seen through it. Zooids are plentiful, opening radially around the surface of the lobe and extending into the base. No systems are evident.

Zooids are about 6 mm. long in the expanded state. The postabdomen is half of the body length and the thorax and abdomen are equal. The branchial aperture is on a short siphon and is six-lobed ; the atrial aperture is antero-dorsal and on a short siphon below a long undivided languet. There are 10–11 rows of stigmata on each side of the body, with about 20 in each row. The alimentary canal is long and it sometimes may be twisted as in *Polyclinum*. The stomach has 10–12 longitudinal folds.

Discussion.—These specimens are very closely related to *A. glabrum* Verrill from Arctic regions and *A. californicum* Ritter & Forsyth from California, and although the zooids are identical with those described for *A. savignyi* Michaelsen from the Red Sea, the test is different. The test in the present colonies is very like the transparent test in some species of *Polyclinum*, and it is interesting that some of the zooids in the present colonies have the intestine twisted so that the rectum crosses the oesophagus, also a characteristic of *Polyclinum*.

Despite the differences from *A. savignyi* noted above it does not seem advisable to separate the present specimens from it as specifically distinct ; the geographical area is the same and a separation of species on the basis of the nature of the test alone is unjustified ; moreover the species of this genus are very variable. It also seems unlikely that

species from the Californian coast and from the Arctic region would occur off southern Arabia.

Sub-Order PHLEBOBRANCHIATA Lahille.

Family Ascidiidae Adams.

Subfamily Ascidiinae Herdman.

Ascidia melanostoma Sluiter.

Sluiter, 1886; Sluiter, 1904; Kott, 1952.

Collection.—Sta. A, 29° 17′ 00″ N., 32° 43′ 00″ E., Red Sea, Otter trawl, 65 m., 6.ix.33.

Previous Records.—East Indies; S.W. Australia.

External Characters.—The specimen is 9 cm. long and 5 cm. wide; the test is firm and black; the branchial aperture is terminal and the atrial aperture arises from the dorsal surface about $\frac{1}{3}$ of the distance from the anterior end.

Internal Characters.—The mantle musculature especially on the right side of the branchial sac is strong; the prebranchial area is very short and the stigmata of the branchial sac commence almost immediately posterior to the branchial tentacles. Although the prebranchial area is so short, it is covered with minute papillae. The dorsal tubercle is a simple U-shaped slit, placed well down in the peritubercular area; there are about 60 simple tentacles of varying sizes. The branchial sac is very long; the dorsal lamina is a toothed membrane, ribbed on the left-hand side, and the oesophagus opens half-way down the branchial sac. The branchial sac itself has papillae at the intersection of longitudinal and transverse vessels but there are no intermediate papillae; there are six stigmata in each mesh. The alimentary canal forms a double loop.

Discussion.—*Ascidia melanostoma* has not been taken previously in this area, although there is another, externally similar form, *Ascidia nigra* (Sav.) which has been recorded from the Red Sea and the Gulf of Aden. There is no question, however, of these two being synonyms, since *A. nigra* has the very distinctive character of separate openings of the dorsal tubercle into the branchial sac. Both forms occur in the same areas elsewhere and in those areas appear to behave as distinct species.

Ascidia malaca Traustedt.

For literature and synonymy see Michaelsen and Hartmeyer, 1928.

Collection.—Sta. 24, 11° 53′ 42″ N., 51° 13′ 12″ E., off Cape Guardafui. Conical dredge, 73–200 m., 9.x.33.

Previous Records.—Mediterranean; Fremantle, Western Australia.

External Characters.—This specimen is 7 cm. long and only 2 cm. wide. The test is whitish, semi-transparent, firm and gelatinous. The branchial aperture is terminal, fairly long and directed posteriorly; the atrial aperture is also terminal but is directed anteriorly.

Internal Characters.—There are fine longitudinal muscle bands in the mantle and an accumulation of circular muscles around the siphons. The dorsal tubercle, a simple U with outwardly directed horns, is present at the base of the atrial siphon, which arises a

short distance down the branchial sac ; the stigmata of the branchial sac extend well up into the posteriorly directed part of the branchial siphon so that the prebranchial area is actually short and papillated. Therefore, although the branchial siphon externally appears long, it is in fact very short. There are about twenty-four branchial tentacles. The dorsal lamina is a double membrane in the anterior quarter of its length, but joins into a single membrane posterior to this ; it is ribbed on the right-hand side and has small pointed languets on the edge of the membrane at the end of each rib. There are occasional intermediate papillae in the branchial sac ; there are 6–7 stigmata in each mesh, but some of the stigmata are irregular and extend over more than one mesh. The oesophageal opening is terminal at the posterior end of the branchial sac. The alimentary canal is confined to the posterior quarter of the branchial sac and forms a double loop ; the stomach is long and spindle-shaped, with internal folds. The anus opens just anterior to the pole of the intestinal loop and has a lobed margin.

Discussion.—The posteriorly directed branchial siphon is characteristic of many species of this genus, particularly those with a rather thick, rigid, gelatinous test and especially of the *Phallusia*-type species with the separate openings of the dorsal tubercle into the branchial sac. Although this specimen is smaller than any previously referred to *A. malaca*, and the branchial siphon is not quite so long, the condition of the branchial siphon, the similarity of the branchial sac and alimentary canal and the situation of the atrial siphon are diagnostic of the species which appears to have a continuous distribution from the Mediterranean, through the Red Sea to the west coast of Australia.

II. Order PLEUROGONA (Huus).

Sub-Order STOLIDOBRANCHIATA (Lahille).

Family Styelidae Sluiter.

Styela canopus Savigny.

For literature and synonymy see Michaelsen, 1918*a*.

Collection.—Sta. A, 19° 17′ 00″ N., 32° 43′ 00″ E., Red Sea. Otter trawl, 65 m., 6.ix.33.

Previous Records.—Red Sea, Gulf of Suez.

Discussion.—One specimen only is present in the collection and this conforms with other descriptions previously given for the species. Although there are closely related forms present over a wide area, this particular species has very constant characters and exists, as far as present records show, in the very limited area of the Red Sea and the Gulf of Aden.

Polycarpa thelypanes (Sluiter).

Sluiter, 1904 ; Kott, 1952.

Collection.—Sta. 27, 11° 57′ 12″ N., 50° 35′ 00″ E., north of Cape Guardafui. Otter trawl, 37–91 m., 12.x.33.

Previous Records.—Sulu Archipelago ; Albany, Western Australia.

External Characters.—The present specimen is very damaged. The test is brittle with sand. The body is more or less oval and the two apertures on fairly long siphons are

placed at either end of the upper surface. Both of these apertures are inclined slightly posteriorly.

Internal Characters.—The mantle is very thin and with only weakly developed musculature. The branchial sac has four folds but the condition of the specimen did not enable the number of vessels on the folds to be counted ; there are six longitudinal vessels between the folds and about four stigmata in each mesh ; these stigmata are fairly long and seem to be more regular than those previously described for this species. The alimentary canal describes a single wide loop which is confined to the posterior part of the body ; the stomach is elongate with longitudinal folds. Elongate polycarps are present in two rows around the ventral part of the body.

Discussion.—There are differences in the branchial sac and the external appearance of this specimen compared with other specimens described and assigned to *P. thelypanes*. Sluiter's specimen had rudimentary folds ; the specimen from Western Australia has rounded, but well developed folds ; the present specimen appears to have well developed folds, which may in some way be an artefact of the flattened and damaged branchial sac ; this character, therefore, may be a variable one. Externally the specimen is very similar to *P. manaarensis* Herd. (Herdman, 1906) but internally is entirely different. Therefore, since the external appearance of many species is known to be affected by the environment, this also must be considered as probably variable within the species. The specimen is, however, identical with *P. thelypanes* in respect of its alimentary canal and gonads.

Polycarpa aurita (Sluiter).

For literature and synonymy see Kott, 1952.

Collection.—Sta. 45, 18° 03′ 30″ N., 57° 02′ 30″ E., off southern Arabia. Triangular dredge, 38 m., 29.x.33.

Previous Records.—Malaya ; Cape Jaubert, Western Australia ; Barrier Reef, N.E. Australia.

Description and Discussion.—The only character in which the present specimen differs from previous descriptions of *P. aurita* is in having a dorsal tubercle with simple longitudinal slit. The elaborate dorsal tubercle described previously for the species, is however merely an elaboration of this single form, and the connective from the stomach to the intestine is distinctive. Cylindrical endocarps are present in the loop of the gut.

Polycarpa cryptocarpa (Sluiter).

Sluiter, 1885 ; Hartmeyer, 1906.

Collection.—Sta. 53, 19° 22′ 36″ N., 57° 53′ 00″ E., off southern Arabia. Triangular dredge, 13·5 m., 2.xi.33. Sta. 45, 18° 03′ 30″ N., 57° 02′ 30″ E., off southern Arabia. Triangular dredge, 40 m., 29.x.33.

Previous Records.—East Indies and Japan.

External Characters.—A large number of specimens are present from the above stations in large clumps of individuals ; some have a short stalk posteriorly but others are completely sessile. The test is leathery and smooth. The branchial and atrial apertures are both anterior and sessile. A living specimen matched in sunlight against a Ridgway colour chart was " Ochraceous Orange ".

Internal Characters.—The mantle musculature is strong and the mantle strongly adherent to the test in the preserved animal. The branchial tentacles are long and slender, of varying lengths ; the dorsal tubercle is a large cushion with many apertures. The branchial sac has the following arrangement of longitudinal vessels : E2(8), 3(10), 3(9), 3(3), 1 DL, and there are 8–9 stigmata in the meshes between the folds. The alimentary canal encloses a circular endocarp and the anus is fringed by many small lobes. There are about 25 polycarps scattered over the body wall on the left and about twenty on the right.

Discussion.—These specimens are very similar to *Polycarpa pedunculata* Heller (Kott, 1952) and belong to the " pedunculata " group of this genus, all with large endocarp enclosed by the loop of the alimentary canal. *Polycarpa mytiligera* (Sav.) (Michaelsen, 1918) is the species of this group previously reported from the Red Sea area, but it has, however, about 20 stigmata in the meshes between folds and has longer siphons. Therefore, although in *P. mytiligera* the dorsal tubercle has the same multiplicity of apertures as the *P. cryptocarpa*, the two are regarded as distinct.

Alleocarpa similis (Sluiter) ?

Sluiter, 1904.

Collection.—Sta. 53, 19° 22′ 36″ N., 57° 53′ 00″ E. off southern Arabia. Triangular dredge, 13·5 m., 2.xi.33.

Previous Records.—East Indies.

External Characters.—The zooids are 1–2 mm. long, dorso-ventrally flattened and enclosed in a colourless test investing the stalks of *Podoclavella detorta*. The test is very tough. Sometimes the zooids are very close together, but at other times they are well separated and there is a large extent of test with ramifying blood vessels between. The colony is very similar to those of species of *Chorizocarpa* (Herdman) (Herdman, 1899). The apertures are both on the upper surface of the zooid and are sessile.

Internal Characters.—The branchial sac has four longitudinal vessels and no folds. There are about four stigmata between each longitudinal vessel and nine rows of long rectangular stigmata. The alimentary canal occupies the posterior half of the left side of the zooid and, due to dorso-ventral flattening, is ventrally situated ; it forms a double loop. The stomach is rounded with 12 well developed longitudinal folds and a large and curved coecum posteriorly No gonads are developed.

Discussion.—As the zooids of this colony are smaller than those previously described for related species, and since there are no gonads present, the colonies are presumably very young and their identification is not certain. Despite similarities to *Chorizocarpa* spp. (Herdman) in respect of the branchial sac and the form of the colony, the gland of the alimentary canal differs ; instead of being branched and ramifying over the intestine, it is here a simple curved coecum. In this latter character it agrees with *Alleocarpa similis* (Sluiter) and this resemblance with similarities of the colony, gut and branchial sac seem to relate it more closely to this species than to any other.

Botrylloides nigrum Herdman.

For literature and synonymy see Kott, 1952.

Collection.—Sta. 27, 11° 57′ 12″ N., 50° 35′ 00″ E., north of Cape Guardafui. Otter trawl, 37–91 m., 12.x.33.

Previous Records.—Red Sea, Mediterranean, Malaya, South Africa, Australia, north west Europe and North Atlantic.

Family Pyuridae Hartmeyer.

Herdmania momus (Sav.) var. *kyamanensis* Michaelsen.

For literature and synonymy see Michaelsen, 1918*a*.

Collection.—Sta. 27, 11° 57′ 12″ N., 50° 35′ 00″ E., north of Cape Guardafui. Otter trawl, 37–91 m., 12.x.33.

Previous Records.—Red Sea.

Discussion.—This form of a widely distributed species shares with *Styela canopus* Savigny the distinction of being one of the few species in this collection whose recorded distribution is limited to the Red Sea area. Unlike *S. canopus*, however, other varieties of the species with a wider distribution are also present in the area: *H. momus* var. *curvata* Kott (Kott, 1952) from north east Australia is synonymous with *H. momus* var. *typica* (Sav.) previously recorded only from the Red Sea area; and *H. momus* var. *pallida* (Heller) is present in the Gulf of Aden, Malaya, South Africa and the West Indies.

Sub-Order ASPIRICULATA Seeliger.

Family Hexacrobylidae. Seeliger.

Hexacrobylus sp.?

(Text-fig. 17.)

Collection.—Sta. 54, 21° 50′ 00″ N., 59° 52′ 00″ E., off southern Arabia. Agassiz dredge, 952 m., 3.xi.33. Sta. 185, off southern Arabia. Agassiz dredge, 2000 m., 5.v.34.

External Characters.—There are several individuals from the two stations. They are 0·5–1 cm. in diameter, and laterally flattened. The test is thin and transparent, but tough: posteriorly there is a thick mass of fine hair-like extensions of the test, tangled with some sand. The apertures are at opposite ends of the upper surface. The branchial aperture is surrounded by a thickened area of the test, about 3 mm. in diameter, and limited by six hollow extensions of the test (Text-fig. 17) into which muscular expansions of the mantle protrude. These extensions are as wide as they are long, have about three primary lobes and are secondarily indented many times and covered by thin hair-like processes. In the contracted condition, these lobes exactly fit together to cover the branchial aperture.

Internal Characters.—The zooids inside the test are hardened and indistinguishable. A small portion of the branchial sac, however, shows the large wide open meshes present in species described from deep water.

Discussion.—Due to the hardened and indistinguishable condition of the body of the zooid inside the test, these animals cannot be assigned with certainty to any previously described form. The branchial projections from the test are, however, distinctive and have been described only for this rare genus. This with the wide rectangular meshes of the branchial sac suggest that it may be a species of *Hexacrobylus*, of which there are records from Malaya (Sluiter, 1905) and Ceylon (Oka, 1913).

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